Quantum Physics Correction to Relativistic Velocity Addition Formula

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ABSTRACT

Albert Einstein proposed in *The Special Theory of Relativity* that matter and energy are equivalent. Subsequently, Louis de Broglie proposed the existence of matter waves. It stands to reason to theorize that if matter and energy are equivalent, then matter waves and energy waves should both propagate at the speed of light c. In the everyday world, though, this does not appear to be the case since we are only familiar with subluminal velocities of matter. To reconcile this observation with our hypothesis, we must further theorize that matter propagates by discrete motion based on the binary set of velocities $S = \{c, 0\}$. Therefore, by alternating between motion and rest, a particle in motion will appear to travel at subluminal velocities. In this paper, this model of motion leads directly to a velocity addition formula similar to that derived in *Special Relativity*. The two formulas agree when we calculate the velocity of light relative to an observer, but for motion at subluminal velocities the formula derived in this paper suggests a correction to the *Special Relativity* formula. Since this paper relies entirely on quantum physics, this proposed correction is an important pointer to how the harmonization of quantum physics with relativistic physics should proceed.

Key words: *Discrete motion, quantized velocity, wave-particle duality, matter waves, velocity addition*

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1. Introduction

The motion of a particle by discrete motion is characterized by alternate bursts and freezes of motion. In the burst-of-motion phase (call it the ephemeral flight) the particle travels at the speed of light while in the freeze-of-motion phase (call it the ephemeral pause) it is stationary. Subluminal velocities arise from the interplay between the respective durations of the ephemeral pause and the ephemeral flight. Discrete motion initially requires matter to assume a state in which matter waves come into being. I shall call it the x-state. Suppose that an interval AB is the smallest moveable distance in the particle state. At point A, the particle is converted into the x-state; from A to B it moves in the x-state as matter waves at velocity c; and at point B it changes from the x-state back into a particle. The time taken for the state transition from ordinary matter to x-state and back to ordinary matter is what accounts for all subluminal velocities. We shall call the transition from ordinary matter to the x-state sublimation and from the x-state back to ordinary matter condensation.

2. Methods and Postulates

i. Postulate 1

Matter propagates by discrete motion.

ii. Postulate 2

The universal set of fundamental velocities for discrete motion is the binary set $S = \{c, 0\}$, where c is the velocity of light.

3. Results: Mathematical descriptions of discrete motion

a. Least displacement of a particle

Suppose that a particle of mass m moves from point A to point B at velocity v and that the length AB is its least displacement possible in particle state. Since the particle exists in the ordinary state of matter only at points A and B, the time taken to travel the distance AB is the period of the particle. Therefore, the least displacement possible *in particle state* is equal to the de Broglie wavelength of the particle.

i.e. smallest possible displacement *in particle state* $\Delta x = (\frac{h}{mv})$ .... *(i)*

A trivial consequence of *equation (i)* is that matter in motion assumes the particle state at integral multiples of its de Broglie wavelength.

b. Duration of the ephemeral flight &the ephemeral pause

Suppose t_t= overall time a particle of mass m takes to move from A to B at average velocity v

t_c= time spent to move from A to B at the speed of light in x-state of matter

t_s= time taken by particle of matter to sublimate at point A and to condense at point B

Then $t_t = t_s + t_c$

Therefore, $t_s = \frac{h}{mv}(\frac{1}{v} - \frac{1}{c})$

Or $t_s = \frac{h}{mv^2}(1 - \frac{v}{c})$ ……………………………….*(ii)*

This is the duration of the ephemeral pause – the length of time that Zeno of Elea noted in his paradox of the arrow [1].

The duration of the ephemeral flight $t_c = \frac{h}{mvc}$ …………………………*(iii)*

c. Probability that particle is in ephemeral flight or ephemeral pause

The probability that the particle is in motion (i.e. in ephemeral flight) = $\frac{t_c}{t_c + t_s} = \frac{v}{c}$ ………..*(iv)*

The probability that the particle is stationary (i.e. in ephemeral pause) = $\frac{t_s}{t_c + t_s}$ = $(1 - \frac{v}{c})$……*(v)*

d. Calculation of relative velocity

Suppose that two particles *A* and *B* are in motion along parallel trajectories at velocities v_A and v_B respectively. What would be the velocity of *B* relative to *A* (designated v_{BA}) during a time interval Δt?

According to our model of motion, *B* moves relative to *A* in three circumstances:

- *when A is stationary and B is in motion*
  The duration of this phase = $\Delta t\left(\frac{v_B}{c}\right)\left(1 - \frac{v_A}{c}\right)$.
  The factor $\left(\frac{v_B}{c}\right)\left(1 - \frac{v_A}{c}\right)$ is the probability that *B* is in motion at velocity *c* and A is stationary *(see equations (iv) & (v))*.
- *when A is in motion and B is stationary*
  The duration of this phase = $\Delta t(\frac{v_A}{c})\left(1 - \frac{v_B}{c}\right)$.
  The factor $(\frac{v_A}{c})\left(1 - \frac{v_B}{c}\right)$ is the probability that *A* is in motion at velocity *c* and B is stationary. *(see equations (iv)& (v))*.
- *when both A and B are in motion*
  The duration of this phase = $\Delta t(\frac{v_A v_B}{c^2})$.
  The factor $(\frac{v_A v_B}{c^2})$ is the probability that both *A* and *B* are in motion and are moving independently of each other at relative velocity v_{BA}.

Therefore, the total distance moved by *B* relative to *A*,

$$v_{BA}\Delta t = c\Delta t\left(\frac{v_B}{c}\right)\left(1 - \frac{v_A}{c}\right) \pm c\Delta t(\frac{v_A}{c})\left(1 - \frac{v_B}{c}\right) + v_{BA}\Delta t(\frac{v_A v_B}{c^2})$$

Note that v_{BA} must maintain the same sign on both sides of the equation. Depending on which sign we choose for the second term of the equation above, we get one of two equations:

i.e. $$v_{BA} = v_B + v_A - \frac{2v_A v_B}{c} + v_{BA}(\frac{v_A v_B}{c^2})$$

or $$v_{BA} = v_B - v_A + v_{BA}\left(\frac{v_A v_B}{c^2}\right)$$

So $$v_{BA} = \frac{v_B + v_A - \frac{2v_A v_B}{c}}{1 - \frac{v_A v_B}{c^2}} \qquad \text{……………….(vi)}$$

Or $$v_{BA} = \frac{v_B - v_A}{1 - \frac{v_A v_B}{c^2}} \qquad \text{…………….(vii)}$$

Equation (vii) is similar to the relativistic velocity addition formula [2, p. 1230] but *equation (vi)* is different although it gives the same result when we calculate the velocity of light relative to an observer. *Equation (vi)* in effect suggests that a correction to the relativistic velocity addition formula is necessary.

4. Discussion

a. *Implications of travel at speed of light & correction to relativistic velocity addition formula*

Historically, the concept of spacetime was founded on *Special Relativity* while *General Relativity* was founded on Hermann Minkowski's model of spacetime. If corrections suggested in this paper to *Special Relativity* are valid, they may necessitate changes to the prevailing model of spacetime and, consequently, to *General Relativity*. Since such changes would have been inspired by quantum physics, they would serve to harmonize quantum physics and *General Relativity*.

5. Conclusion

This paper has proposed a correction to the relativistic velocity addition formula. The correction was indicated in a formula for velocity addition derived purely using quantum physics. The model of motion on which the derivation was based stipulates travel at the speed of light for matter waves. This contradicts *Special Relativity*. Since Minkowski spacetime was founded on *Special Relativity* while *General Relativity* was founded on Minkowski spacetime, this contradiction of *Special Relativity* probably implies a contradiction of *General Relativity*. Therefore, assimilation of this proposed correction in *Special Relativity* would foster the harmonization of quantum physics and *General Relativity*,

As a recommendation for further study, I suggest research into how the capacity of matter waves to travel at the speed of light and the proposed correction to the relativistic addition formula affect the Minkowski model of spacetime.

6. Declarations

The author certifies that he has no affiliation with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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